

02 SEPTEMBER 2003 (02.09.03)

REC'D 12 SEP 2003

WIPO

PCT

PA 1040705

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

July 17, 2003

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM
THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK
OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT
APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A
FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 60/394,921

FILING DATE: July 10, 2002

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH
RULE 17.1(a) OR (b)

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS





N. WOODSON

Certifying Officer

BEST AVAILABLE COPY



07-11-02

60394921.071002
i-pmPlease type a plus sign (+) inside this box →

PTO/SB/16 (10-01)

Approved for use through 10/31/2002 OMB 0851-0092
U S Patent and Trademark Office U S DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EU14061583US

D996 U.S. PTO
07/10/02

INVENTOR(S)		
Given Name (first and middle if any)	Family Name or Surname	Residence (City and either State or Foreign Country)
Yuqi Tuyu	Cai Xie	Ontario, Canada Ontario, Canada
<input checked="" type="checkbox"/> Additional inventors are being named on the p.2 separately numbered sheets attached hereto		
TITLE OF THE INVENTION (500 characters max.)		
Elastomeric Conductive Plates and Method of Fabrication		
Direct all correspondence to: CORRESPONDENCE ADDRESS		
<input checked="" type="checkbox"/> Customer Number <input type="text" value="23906"/> OR <small>Type Customer Number Here</small>		<input type="text" value="*23906*"/> <small>PATENT TRADEMARK OFFICE</small>
<input type="checkbox"/> Firm or Individual Name Address Address City Country		
		State ZIP Telephone Fax
ENCLOSED APPLICATION PARTS (check all that apply)		
<input checked="" type="checkbox"/> Specification Number of Pages <input type="text" value="17"/> <input checked="" type="checkbox"/> Drawing(s) Number of Sheets <input type="text" value="3"/> <input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76		
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT		
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. <input type="checkbox"/> A check or money order is enclosed to cover the filing fees <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: <input type="text" value="04-1928"/> <input type="checkbox"/> Payment by credit card. Form PTO-2038 is attached.		<small>FILING FEE AMOUNT (\$)</small> <input type="text" value="160"/>
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.		
<input checked="" type="checkbox"/> No. <input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: _____.		

Respectfully submitted,

SIGNATURE

Date TYPED or PRINTED NAME REGISTRATION NO

(If appropriate)

TELEPHONE Docket Number **USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington,

60394924 . 071003

PROVISIONAL APPLICATION COVER SHEET
Additional Page

PTO/SB/16 (10-01)

Approved for use through 10/31/2002 OMB 0651-0032
GSA GEN. CTR. M-2 DEPARTMENT OF DEFENSE

U S Patent and Trademark Office U S DEPARTMENT OF COMMERCE
www.uspto.gov

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

		Docket Number	DC8504 US NA
INVENTOR(S)/APPLICANT(S)			
Given Name (first and middle [if any])		Family or Surname	Residence (City and either State or Foreign Country)
Divya		Chopra	Ontario, Canada
Michael		Waller	Ontario, Canada
Jay A.		Peters	Ontario, Canada

Number 2 of 2

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

TITLE OF INVENTION**Elastomeric Conductive Plates And Method Of Fabrication****Field of the Invention**

The present invention relates to improved electrically conductive flow field separator plates for use in proton exchange membrane fuel cells and to a method of making such plates. In particular, the plates of the present invention are elastomeric so as to provide excellent sealing at the plate/membrane interface without the need for a separate sealing gasket.

Background of the Invention

The cost of fuel cells must be reduced dramatically to become commercially viable on a larger scale. The cost of the flow field plates, including the cost of forming the flow field onto the plate, represents a significant portion of the total cost within a fuel cell. Therefore, cost reduction of the flow field plate is imperative to enable fuel cells to become commercially viable on a larger scale. The cost reduction can be manifested in several ways including reducing the cost of the materials that are used to make the plate, reducing the manufacturing cost associated with making the plate, and/or improving the function/performance of the plate within a fuel cell so that the same fuel cell can produce electrical power more efficiently and/or produce more electrical power within the same fuel cell. Typically, developments in the flow field plate have attempted to optimize the trade-offs by reducing material cost and/or manufacturing cost while compromising performance-in-use.

A typical proton exchange membrane (PEM) fuel cell comprises several components. These components typically include a membrane, catalyst layers on the anode and cathode sides of the membrane known as the gas diffusion electrodes, and gas diffusion backings on each side. The membrane, electrode layers and gas diffusion backings are laminated together to create the membrane electrode assembly (MEA). Each MEA is sealed between two thermally and electrically conducting flow field plates. The seals are typically created by separate gasket components made of TEFILON® film, silicone or some elastomer material, such as VITON® fluoroelastomer available from DuPont Dow

Elastomers. Each fuel cell is then "stacked" with other cells to achieve the required voltage and power output to form a fuel cell stack. Each stack is subjected to a compressive load to ensure good electrical contact between individual cells.

In operation, fuel is introduced on the anode side of the cell through flow field channels in the conductive flow field plates. The channels uniformly distribute fuel across the active area of the cell. The fuel then passes through the gas diffusion backing of the anode and travels to the anode catalyst layer. Air or oxygen is introduced on the cathode side of the cell, which travels through the gas diffusion backing of the cathode to the cathode catalyst layer. Both catalyst layers are porous structures that contain precious metal catalysts, carbon particles, ion-conducting NAFION® particles, and, in some cases, specially engineered hydrophobic and hydrophilic regions. At the anode side, the fuel is electrochemically oxidized to produce protons and electrons. The protons must travel from the anode side, across the ion-conducting electrolyte membrane, and finally to the cathode side in order to react with the oxygen at the cathode catalyst sites. The electrons produced at the anode side must be conducted through the electrically conducting porous gas diffusion backing to the conducting flow field plates. As soon as the flow field plate at the anode is connected with the flow field plate at the cathode via an external circuit, the electrons will flow from the anode through the circuit to the cathode. The oxygen at the cathode side will combine protons and electrons to form water as the by-product of the electrochemical reaction. The by-products must be continually removed via the flow field plate at the cathode side in order to sustain efficient operation of the cell. Water is the only by-product if hydrogen is used as the fuel while water and carbon dioxide are the by-products if methanol is used as the fuel.

Flow field separator plates are the outer components of each fuel cell and are in contact with the gas diffusion backing layers. The plates are called bipolar plates (BPPs) when used in a bipolar fuel cell stack. The BPPs provide many functions that place unusual demands on their materials of construction. BPPs have channels formed in their surfaces called "flow fields". Flow fields are precision-engineered channels designed to optimize fluid flow across the active

area of the fuel cell and thereby increase fuel cell performance. Dramatic gains in kW per m² power density achieved over the last ten years is due in large part to improved flow field design. BPPs also function to conduct electrons and heat from the active layer to an external load and must maintain this conductivity over a long operating life in a highly corrosive environment. Both electrical and thermal conductivity at the interface between the gas diffusion backing and the plate are critical for minimising fuel cell resistance. BPPs further provide physical separation of the oxidant and fuel in a bipolar fuel cell stack design and must maintain this separation throughout the lifetime of the stack to ensure a safe operation.

BPPs provide structural integrity within each fuel cell and within the fuel cell stack as a whole. Structural integrity is essential to a fuel cell stack in order to maintain adequate seals within each fuel cell for the lifetime of the fuel cell stack. Structural integrity is also important to provide uniform compressive stress across the active area of the fuel cell and thereby maintain optimum performance of the fuel cell stack. Because of their multi-purpose role in a fuel cell, BPPs have a number of requirements to meet. BPPs should have good electrical conductivity, good mechanical or structural properties and high chemical stability in the chemically reactive fuel cell environment. Because of their gas distribution role, BPPs should preferably be made of a gas impermeable material and be formed with complex gas delivery channels across its surface.

In some hydrogen-based PEM fuel cells, BPPs also act as "water transport plates". The NAFION® membranes need water to function. These water transport plates are made permeable to water and relatively impermeable to hydrogen and air. Water produced at the cathode side of the cell gets transported through the plate to the anode side of the next cell in a bipolar stack design. The internally produced water is used on the anode side to humidify the membrane. This approach eliminates the need for a separate membrane humidification subsystem, thereby simplifying the balance-of-plant requirements.

Because of the performance requirements of conductive flow field plates and the aggressive conditions inside the fuel cell, the material options for constructing conductive flow field plates are limited. In general, graphite has been used for conductive flow field plates because of its high electrical conductivity and

resistance to corrosion. Graphite however is typically produced in 6 mm thick slabs, adding both weight and bulk to the fuel cell and decreasing its power density when in use. Further, machining flow fields onto graphite plates is not cost effective.

Past attempts at solving the various requirements for fuel cell plates have also included the use of metal plates. The use of metal plates result in higher weight per cell, higher machining costs and possibly corrosion problems.

Carbon/graphite composites made with plastic polymers as binders have long been identified as a promising alternative to traditional materials in flow field plates. In US Patent No. 4,339,322 to Balks et al, there is disclosed a bipolar current collector plate for electrochemical cells comprising a moulded aggregate of graphite and a thermoplastic fluoropolymer particles reinforced with carbon fibres to increase strength and maintain high electrical conductivity.

In current fuel cell stacks designs, a sealing gasket such as an elastomeric gasket made of VITON®, must be used between the conductive flow field plates and the membrane in order to prevent any fuel leakage at the interface and to prevent compressive damage to the membrane caused by the clamping force applied on the fuel stack. The requirement to have a sealing gasket at each interface increases the cost of a fuel cell stack by complicating fuel cell design and also by increasing production cycle times to make fuel cell stacks.

US Patent No. 5,536,598 to Lafollette discloses bipolar plates comprising a composite of long carbonstrands, a filler of carbon particles and a fluoroelastomer. A separate sealing material is necessary, however, to create a seal around the bipolar plates.

The disclosures of all patents/applications referenced herein are incorporated herein by reference.

There remains a need therefore to eliminate or at least reduce the requirement for separate sealing gaskets between the conductive flow field separator plates and the membranes used in fuel cells.

Summary of the Invention

The conductive flow field separator plates of the present invention are not only electro-conductive but are also elastomeric so that in the fuel cell stack the frame portions of the plates provide excellent sealing function at the plate/membrane interface and therefore eliminate the need for separate sealing gaskets. At the same time, the high elasticity of the plates assists in preventing compressive damage to the membrane. Consequently, the fuel cell stack design becomes simpler and the cost of manufacturing the fuel cell stack becomes lower.

In accordance with one aspect of the present invention, there is provided an electrically conductive flow field separator plate for use in a proton exchange membrane fuel cell, comprising a frame portion, a central planar portion within the frame portion and a flow field formed in a surface of the central planar portion, wherein the frame portion is elastomeric so as to be capable of forming a seal with adjacent fuel cell components thereby eliminating the use of separate sealing elements.

In accordance with a second aspect of the present invention, there is provided a method of making an electrically conductive flow field separator plate for use in a proton exchange membrane fuel cell, wherein the plate comprises a frame portion, a central planar portion within the frame portion and a flow field formed in a surface of the central planar portion, the method comprising:

- (a) mixing from about 10 wt% to about 50 wt% of elastomer, from about 50 wt% to about 90 wt% of conductive filler, based on the total amount of elastomer and filler, to form a blend and an effective amount of a cross-linking agent; and
- (b) molding the blend by applying sufficient heat and pressure to form the plate,

wherein the frame portion is elastomeric so as to be capable of forming a seal with adjacent fuel cell components thereby eliminating the use of separate sealing elements.

Brief Description of the Drawings

The preferred embodiments of the present invention will be described with reference to the accompanying drawings in which like numerals refer to the same parts in the several views and in which:

Fig. 1 is a schematic view of a preferred embodiment of the conductive flow field separator plate of the present invention.

Fig. 2 is a schematic cross-sectional view of a single PEM fuel cell with sealing gaskets of the prior art.

Fig. 3 is a schematic cross-sectional view of a preferred embodiment of a single PEM fuel cell of the present invention without sealing gaskets.

Detailed Description of the Preferred Embodiments

The preferred embodiments of the present invention will now be described with reference to the accompanying figures.

With reference to Fig. 1, there is shown a preferred conductive flow field separator plate 10 made in accordance with the preferred method of the present invention. The plate 10 is shown as being generally square in shape, but it will be understood that other shapes can be used such as rectangular and circular. The plate 10 includes a frame portion 12 about the plate's periphery and a central planar portion 14. The plate 10 also includes various manifold holes 16 for distribution of reactants to the fuel cell and for removal of reaction products from the cell. The central portion 14 will also include a flow field pattern (not shown) for distribution of the reactants and removal of reaction product. An example of a flow field pattern is provided in US Patent No. 5,858,569, which is incorporated herein by reference.

The frame portion 12 and central planar portion 14 are preferably of unitary construction and are made of a conductive elastomeric composition. The elastomeric composition is made highly conductive so that the plates 10 can be used as current collectors in fuel cells. The elastomeric plates 10 perform multiple functions: current collection, sealing and prevention of membrane damage. Plates

10 made in accordance with the present invention make fuel cell/stack design simpler (see Fig. 2 and 3) and fuel cell/stack manufacturing cheaper. Plates 10 can be molded using a molding process such as compression, injection, extrusion or blowing molding, including molding the flow field pattern onto a surface or both surfaces of the central planar portion 14. Alternatively, the flow field pattern may be machined onto the surfaces after the plate 10 has been molded. The elastomeric conductive plates 10 generally have a total cross sectional thickness of from about 0.5 mm to about 5 mm.

The plates 10 are made of a composition comprising elastomeric resins and electroconductive fillers. The preferred plate composition comprises from about 10 to about 50 wt%, more preferably from about 15 to about 30 wt%, of the elastomeric resins, and from about 50 to about 90 wt%, more preferably from about 70 to about 85 wt%, of the conductive fillers, based on the total amount of elastomer and filler.

Preferred elastomeric resins include cross-linkable thermoplastic elastomers, thermoplastic vulcanizates, chlorinated elastomers, fluorinated elastomers, silicone elastomers, ethylene-polyethylene-diene-monomer elastomers, natural butyl rubber, and olefinic, polyamide-based, polyester-based and styrenic elastomers, and mixtures of these elastomers.

Typical examples of the elastomers that may be used in the present invention include KALTREZ® perfluoroelastomer, VITON® fluoroelastomer, HYPALON® chlorosulfonated polyethylene, NORDEL® IP hydrocarbon rubber, TYRIN® chlorinated polyethylene and ENGAGE® polyolefin elastomer from DuPont-Dow Elastomers.

A preferred chlorinated elastomer for use in this invention is a chlorosulfonated polyethylene available from DuPont Dow Elastomers as HYPALON®. HYPALON® chlorosulfonated polyethylene has demonstrated long life in harsh environments in applications that require high performance. It is capable of withstanding the heat and acidic environment found in a typical PEM fuel cell.

The preferred fluorinated elastomers are VITON® fluoroelastomer and KALTREZ® perfluoroelastomer available from DuPont-Dow Elastomers. They are well known for their excellent heat resistance and resistance to aggressive chemicals. They provide premium performance and long-term reliability in very harsh environments. Their resistance to heat aging and a broad range of fuels, solvents, and chemicals make them ideal for many demanding applications.

EPDM rubbers (ethylene-polyethylene-diene-monomer) are well known for their excellent weathering and aging resistance. They also have excellent water and steam resistance, maintain their flexibility at low temperatures, and feature excellent resistance to acids.

Silicone elastomers feature excellent resistance to ozone, sunlight and oxidation. They also maintain excellent flexibility at low temperatures and have good resistance to high heat.

The second component of the molding composition is conductive fillers. In accordance with the present invention, the conductive fillers impart electrical conductivity to the final molded elastomeric plate. The conductive fillers useful in the present invention include conductive graphite powders, graphite fibers, carbon black, carbon fibers, conductive ceramic fillers, metal fillers, metal-coated fillers and inherent conductive polymers (ICPs). As specific examples of graphite, there can be mentioned natural graphite, synthetic graphite and graphite fiber.

In a preferred form of the invention, the composite for the plate includes graphite fiber having a length of from about 50 to about 250 microns. Typically the average diameter of the fiber is in the range of 8 to 15 microns. The graphite fiber can be selected from any of the commercially available free flowing fibres. The graphite fiber can be pitch based or PAN-based. In the fiber production process, the fiber is graphitized at very high temperature for high graphite purity. The graphite powder may be selected from synthetic or natural graphite powders in the form of flakes or sphericals and is preferably in the form of flakes. The preferred particle size of the graphite powders is from about 20 to 250 microns.

Other known additives may also be added to the molding composition. These additives include acid acceptors such as magnesia, flame retardants such as halogenated hydrocarbons, plasticizers such as chlorinated paraffins, processing aids such as stearic acid, and vulcanizing agents such as sulfur or peroxide. The total amount of these additives is usually in the range of from 0.1 to 20 parts by weight, based on 100 parts by weight of the elastomer used. In order to enhance the strength of the conductive thermoplastic elastomer composition, a crosslinking agent may be incorporated in the elastomer composition with which the elastomers become crosslinked under heat. General crosslinking agents such as sulfur, a sulfur donor, a quinone crosslinking agent, an organic peroxide and a resinous crosslinking agent can be adopted as the crosslinking agents. Crosslinking agents not containing a metal compound such as zinc oxide may also be used. As examples of the metal compound-free crosslinking agents, there can be mentioned a thiuram sole crosslinking agent such as tetramethylthiuram disulfide or tetraoctylthiuram disulfide, or a combination thereof with a sulfenamide such as N-cyclohexylbenzothiazolsulfenamide; a combined crosslinking agent of triazinethiol with benzothiazole; an organic peroxide sole crosslinking agent such as benzoyl peroxide, hydroperoxide, a dialkyl peroxide or a peroxyketal; and an ultraviolet curing agent. The amount of the crosslinking agent is usually in the range of 0.1 to 10 parts by weight, preferably 0.1 to 5 parts by weight, based on 100 parts by weight of the elastomer.

The molding composition for manufacturing the conductive plates 10 is prepared by mixing the elastomeric resin, conductive fillers and any additives (such as a crosslinking agent) via a compounding machine such as a twin screw extruder, a Buss KneaderTM, a batch mixer (Brabender[®] or Banbury[®] mixer) or a roller-mill (with more than one roller). In a more preferred embodiment, the elastomeric resin and additives are mixed first and then the conductive fillers are added when the resin/additives have been homogeneously mixed and melted. A homogeneous uncured resin/filler/additives mixture is obtained from the mixing/compounding steps.

Preferably, the mixing/compounding temperature will be in the range of from about 20°C to about 100°C, most preferably from about 40°C to about 80° C.

Mixing/compounding will take place for between about 0.1 to about 30 minutes, preferably from about 0.5 to about 20 minutes. The mixing temperature and duration are controlled so that preferably no cross-linking occurs during this mixing step.

The plates 10 are molded by transferring the homogeneous molding composition mixture to a compression mold, applying sufficient pressure on the mold for forming a plate form and heating the mold to the cross-linking reaction temperature of the cross-linking agent in the composition. After sufficient cross-linking, the formed plate is removed from the mold. A shaped conductive plate with or without flow fields is obtained from the molding (curing) steps.

Preferably, the molding (curing) temperature will be in the range from about 120°C to about 200° C, preferably from about 150°C to about 180° C. Molding (curing) generally takes from about 0.1 to about 60 minutes, preferably from about 0.5 to about 20 minutes.

The resulting conductive flow field separator plate 10 has a bulk resistivity of less than 10 ohm-cm and can be in any desired shape, preferably square, rectangular or circular. These conductive plates 10 can be used as current collectors, also called separator, monopolar or bipolar plates, for application in fuel cells, batteries and other electrochemical devices. As well, the composition has good thermal conductivity and therefore can be used as thermal conductive rubber.

Fig. 2 shows a proton exchange membrane fuel cell of the prior art comprising an anode plate 30, a cathode plate 32, a catalyst layer 34, a gas diffusion layer 36, a proton exchange membrane 38 and sealing gaskets 40 and 42. Sealing gaskets 40 and 42 are necessary to provide an effective seal between the anode and cathode plates 30 and 32 and the membrane 38. In Fig. 3, a preferred fuel cell is illustrated in which the sealing gaskets are eliminated. The anode plate 50 and the cathode plate 52 are made in accordance with the present invention and thus are elastomeric. An effective seal is, therefore, created between the plates 50 and 52 and the proton exchange membrane 54.

The fuel cell of Fig. 3 also includes a catalyst layer 56 and a gas diffusion layer 58, however, the sealing gaskets of the prior art are omitted.

The following examples illustrate the various advantages of the preferred method of the present invention.

Examples

Example 1:

A molding composition was prepared with the following components:

- a. 80 wt% synthetic graphite powders with an average particle size of 236 microns;
- b. 3% Magnesium oxide (stabilizer);
- c. 1.2% Vulcup peroxide (cross-linking agent); and
- d. 15.8% Hypalon 6525® chlorinated polyethylene.

All ingredients were added onto a two-roller mill at 34° C, and the gap between the two rollers was regulated from 0.01" to 0.08" while the mill was rotating and the materials were being mixed. The mixing/compounding process was continued for 20 minutes and the compounded mixture was then collected.

The compounded mixture was then deposited into a mold cavity of 6" x 6" x 0.075" and the mold heated to 176° C. When the temperature of the mold reached 176° C, pressure of 4000 PSI was applied on the mold for 20 minutes. The pressure was then released and the molded flat plate removed from the mold.

The bulk resistivity of the molded plate was then measured with a standard Four Point Probe method. The bulk resistivity of the plate was measured as 0.12 ohm-cm.

Example 2

The sealing capability of the molded plates was tested by first machining standard serpentine channels on the surfaces of the molded plates (one anode

and one cathode plate). The plates were then assembled into a fuel cell (100 cm² active area) with a Nafion 117® membrane sandwiched between the two plates. Compressed air was applied to the assembled cell. No air leakage was found until the air pressure was increased to 8 PSI (gauge pressure), which is higher than the normal fuel cell operation air pressure of 4 PSIG. This indicated that the elastomeric plates made in accordance with the present invention can eliminate the need for sealing gaskets in assembling fuel cells.

Although the present invention has been shown and described with respect to its preferred embodiments and in the examples, it will be understood by those skilled in the art that other changes, modifications, additions and omissions may be made without departing from the substance and the scope of the present invention as defined by the attached claims.

DC-8504 US PRV

CLAIMS**What is claimed is:**

1. An electrically conductive flow field separator plate for use in a proton exchange membrane fuel cell, comprising a frame portion, a central planar portion within the frame portion and a flow field formed in a surface of the central planar portion, wherein the frame portion is elastomeric so as to be capable of forming a seal with adjacent fuel cell components thereby eliminating the use of separate sealing elements.

The electrically conductive flow field separator plate of claim 1, wherein the frame portion and the central planar portion are either of different or of unitary construction, and the frame portion and optionally the central planar portion comprising:

- (a) from about 10 wt% to about 50 wt% of elastomer;
- (b) from about 50 wt% to about 90 wt% of conductive filler based on the total amount of elastomer and filler; and
- (c) an effective amount of a cross-linking agent.

The electrically conductive flow field separator plate of claim 1, wherein the frame portion and the central planar portion are of unitary construction, comprising:

- (d) from about 15 wt% to about 30 wt% of elastomer;
- (e) from about 70 wt% to about 85 wt% of conductive filler based on the total amount of elastomer and filler; and
- (f) an effective amount of a cross-linking agent.

The electrically conductive flow field separator plate of claims 2 or 3 comprising from about 0.1 to about 10 parts by weight, based on 100 parts by weight of the elastomer, of the cross-linking agent.

The electrically conductive flow field separator plate of claims 2 or 3 comprising from about 0.1 to about 5 parts by weight, based on 100 parts by weight of the elastomer, of the cross-linking agent.

The electrically conductive flow field separator plate of any one of claims 2 to 5 further comprising from about 0.1 to 20 parts by weight, based on 100 parts by weight of the elastomer, of one or more additives selected from the group consisting of acid acceptors, flame retardants, plastisizers, processing aids, vulcanizing agents and mixtures thereof.

The electrically conductive flow field separator plate of any one of claims 2 to 6, wherein the elastomer is selected from the group consisting of crosslinkable thermoplastic elastomers, chlorinated elastomers, fluorinated elastomers, silicone elastomers, EPDM rubbers, natural butyl rubbers and mixtures thereof.

The electrically conductive flow field separator plate of any one of claims 2 to 6, wherein the conductive filler is selected from the group consisting of conductive graphite powders, graphite fibres, carbon black, carbon fibres, conductive ceramic fillers, metal fillers metal-coated fillers, inherent conductive polymers and mixtures thereof.

The electrically conductive flow field separator plate of any one of claims 2 to 6 wherein the elastomer is a chlorinated elastomer and the conductive filler is selected from graphite powders, graphite fibres and mixtures thereof.

The electrically conductive flow field separator plate of claim 1 comprising flow fields on both surfaces of the central planar portion.

The electrically conductive flow field separator plate of claim 1 having a bulk resistivity of less than 10 ohm-cm.

A method of making an electrically conductive flow field separator plate for use in a proton exchange membrane fuel cell, wherein the plate comprises a frame portion, a central planar portion within the frame portion

and a flow field formed in a surface of the central planar portion, the method comprising:

- (g) mixing from about 10 wt% to about 50 wt% of elastomer, from about 50 wt% to about 90 wt% of conductive filler, based on the total amount of elastomer and filler, to form a blend and an effective amount of a cross-linking agent; and
- (h) molding the blend by applying sufficient heat and pressure to form the plate,

wherein the frame portion is elastomeric so as to be capable of forming a seal with adjacent fuel cell components thereby eliminating the use of separate sealing elements.

The method of claim 12, wherein in step (a), from about 15 wt% to about 30 wt% of elastomer; and from about 70 wt% to about 85 wt% of conductive filler, based on the total amount of elastomer and filler, are mixed to form the blend.

The method of claims 12 or 13 wherein about 0.1 to about 10 parts by weight, based on 100 parts by weight of the elastomer, of the cross-linking agent are mixed to form the blend.

The method of claims 12 or 13 wherein about 0.1 to about 5 parts by weight, based on 100 parts by weight of the elastomer, of the cross-linking agent are mixed to form the blend.

The method of any one of claims 12 to 15 wherein in step (a), from about 0.1 to 20 parts by weight, based on 100 parts by weight of the elastomer, of one or more additives selected from the group consisting of acid acceptors, flame retardants, plastisizers, processing aids, vulcanizing agents and mixtures thereof are mixed.

The method of any one of claims 12 to 16, wherein the elastomer is selected from the group consisting of crosslinkable thermoplastic elastomers, chlorinated elastomers, fluorinated elastomers, silicone elastomers, EPDM rubbers, natural butyl rubbers and mixtures thereof.

The method of any one of claims 12 to 16 wherein the conductive filler is selected from the group consisting of conductive graphite powders, graphite fibres, carbon black, carbon fibres, conductive ceramic fillers, metal fillers metal-coated fillers, inherent conductive polymers and mixtures thereof.

The method of any one of claims 12 to 16 wherein the elastomer is a chlorinated elastomer and the conductive filler is selected from graphite powders, graphite fibres and mixtures thereof.

The method of claim 12 further comprising the step of forming a flow field on a surface the central planar portion.

The method of claim 12 wherein the plate has a bulk resistivity of less than 10 ohm-cm.

The method of claim 12, wherein step (a) is carried out at a mixing temperature of from about 20°C to about 100°C for a mixing time of from about 0.1 to about 60 minutes.

The method of claim 12, wherein step (a) is carried out at a mixing temperature of from about 40°C to about 80°C for a mixing time of from about 0.5 to about 20 minutes.

The method of claim 12, wherein step (b) is carried out at a molding temperature of from about 120°C to about 200°C for a molding time of from about 0.1 to about 60 minutes.

The method of claim 12, wherein step (b) is carried out at a molding temperature of from about 150°C to about 180°C for a molding time of from about 5 to about 20 minutes.

DC-8504 US PRV

Abstract

An electrically conductive flow field separator plate is disclosed for use in a proton exchange membrane fuel cell. The plate comprises a frame portion, a central planar portion within the frame and a flow field formed in a surface of the central planar portion. The frame portion is elastomeric so as to form a seal with adjacent fuel cell components thereby eliminating the use of separate sealing elements. The frame and the central planar portion are of unitary construction and comprise from about 10 wt% to about 50 wt% of elastomer and from about 50 wt% to about 90 wt% of conductive filler.

5

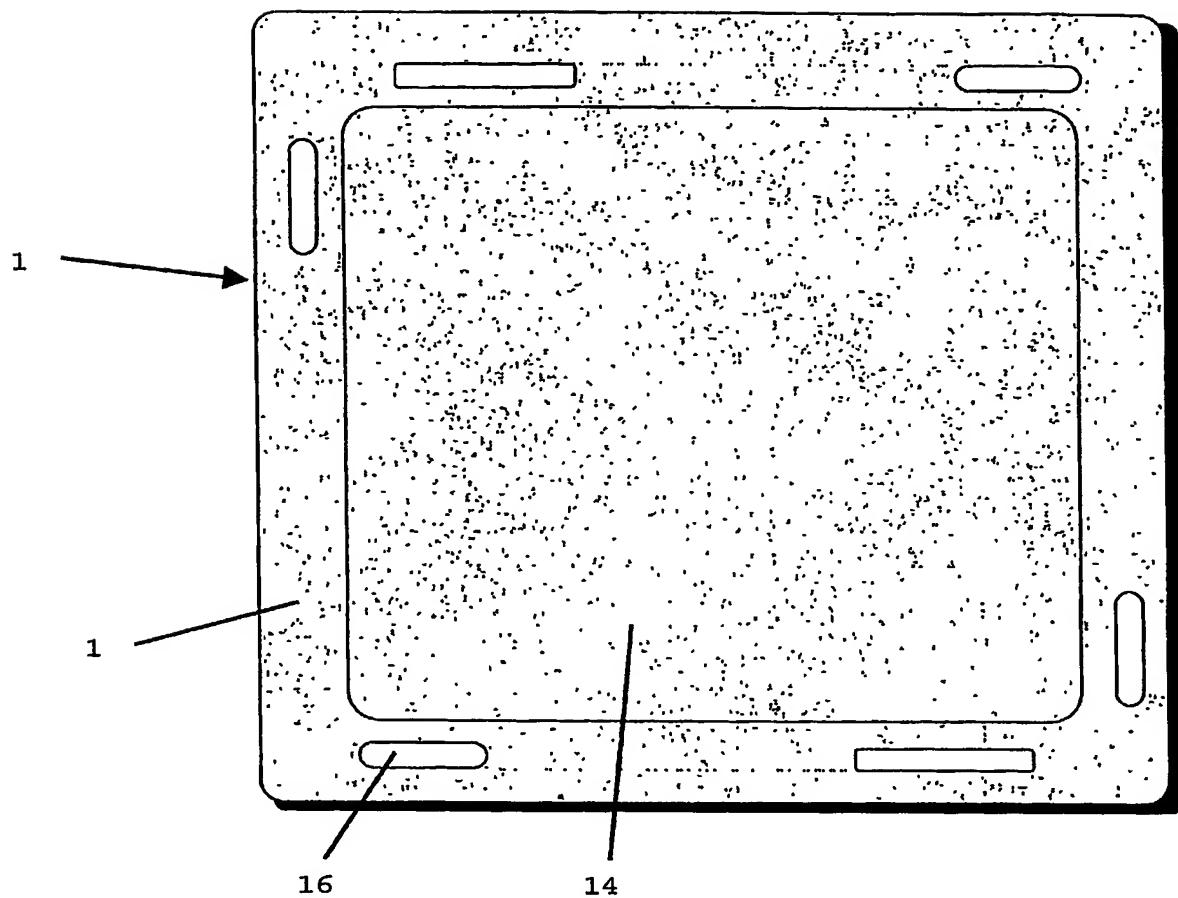


FIG. 1

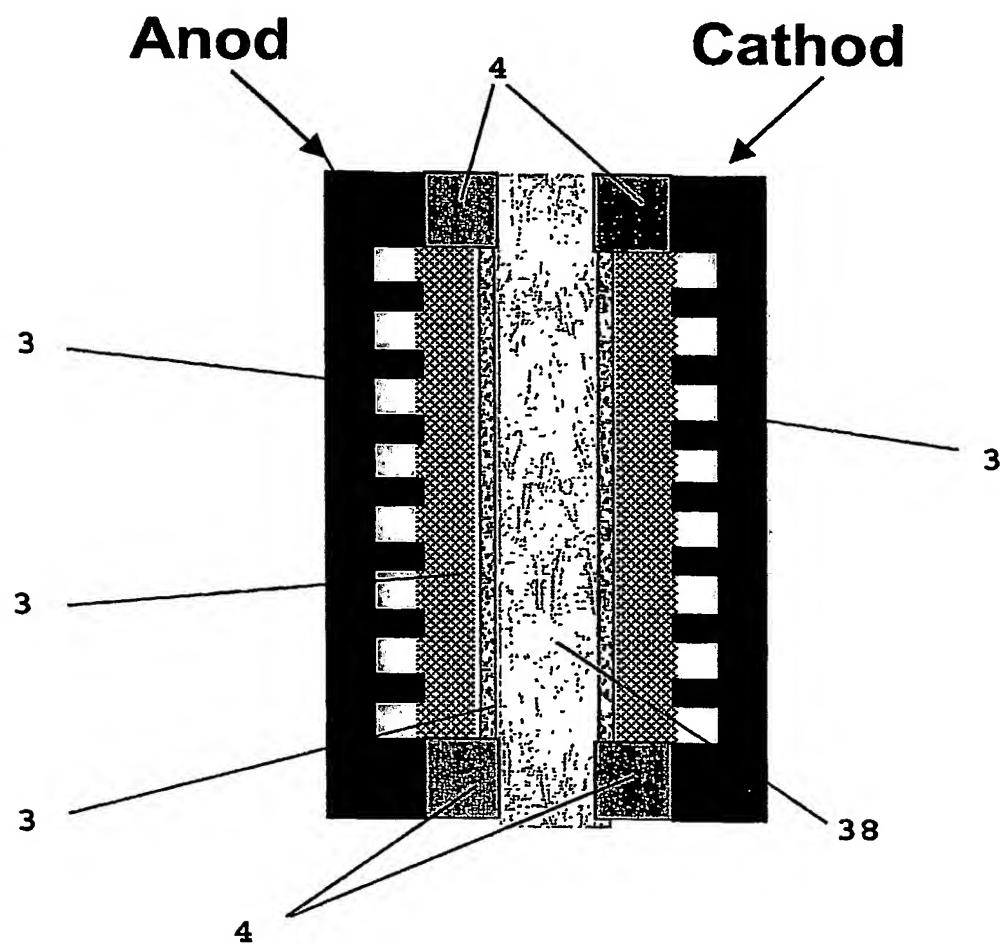


Fig. 2
(Prior Art)

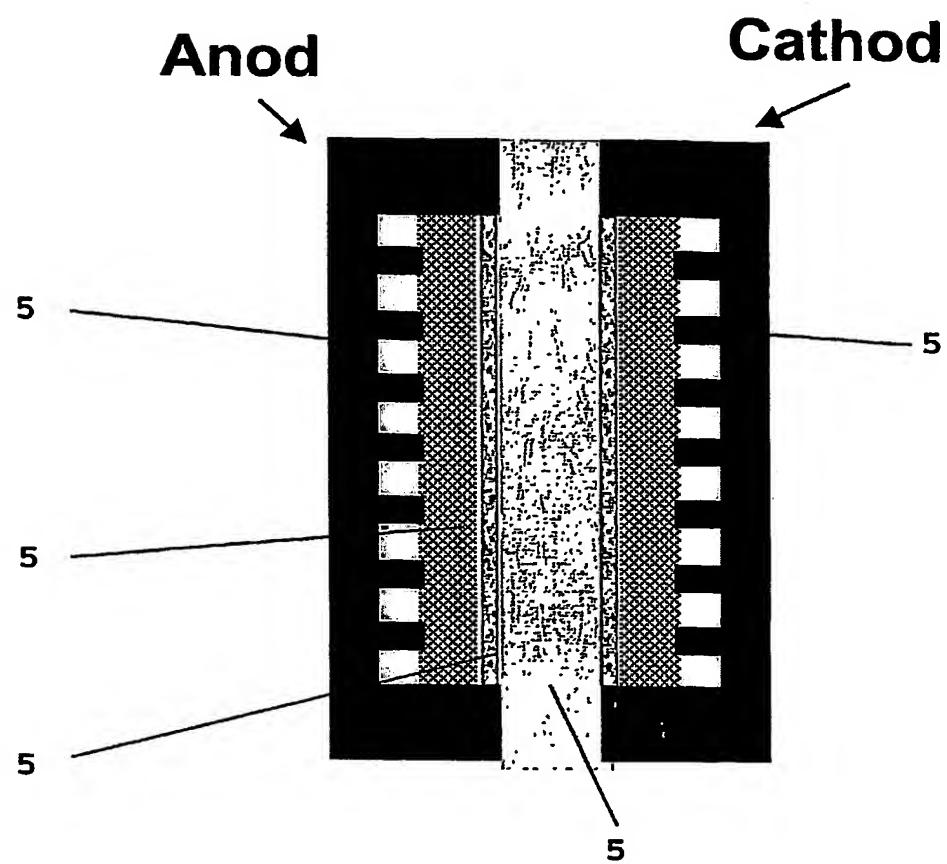


Fig 3

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.